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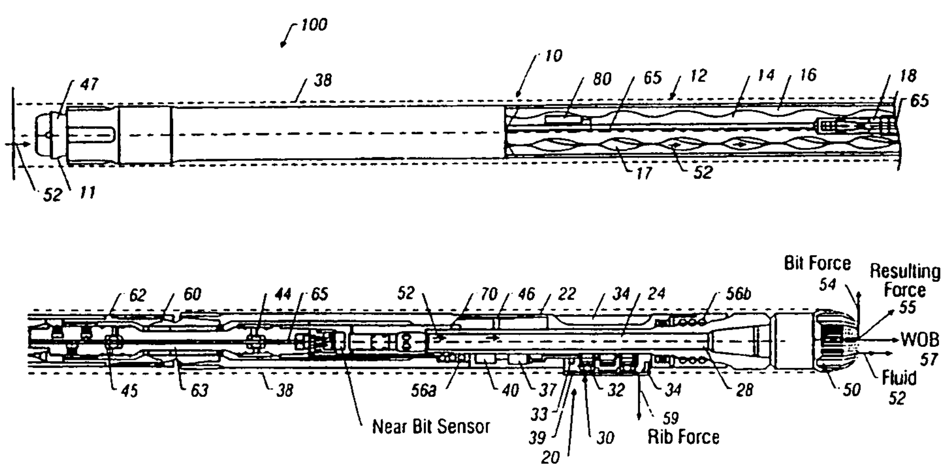

(57) Abstract

The present invention provides a drilling assembly for drilling deviated wellbores. The drilling assembly includes a drill bit (50) at the lower end of the drilling assembly. A drilling motor (10) provides the rotary power to the drill bit. A bearing assembly (20) of the drilling motor provides lateral and axial support to the drill shaft (28) connected to the drill bit. A steering device (30) is integrated into drilling motor assembly. The steering device contains a plurality of force application members (32) disposed at an outer surface of the drilling motor assembly . Each force application member is adapted to move between a normal position and a radially extended position to exert force on the wellbore interior (38) when in extended position. A power unit (40) in the housing provides pressurized fluid to the force application members. A control device (33) for independently operating each of the force application members is disposed in the drilling motor assembly. A control circuit (80) or unit independently controls the operation of the control device to independently control each force application member. For short radius drilling, a knuckle joint (60) is disposed uphole of the steering device to provide a bend in the drilling assembly. During drilling of a wellbore, the force application members are operated to adjust the force on the wellbore to drill the wellbore in the desired direction.

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DRILLING ASSEMBLY WITH A STEERING DEVICE FOR COILED-TUBING OPERATIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to drill strings for drilling boreholes for the production of hydrocarbons and more particularly to a drilling assembly which utilizes a downhole controllable steering device for relatively accurate drilling of short-radius to medium-radius boreholes. The drilling assembly of the present invention is particularly useful with coiled-tubing operations.

2. Description of the Related Art

To obtain hydrocarbons such as oil and gas, boreholes or wellbores are drilled by rotating a drill bit attached to a drill string end. A large proportion of the current drilling activity involves directional drilling, i.e., drilling deviated and horizontal boreholes, to increase the hydrocarbon production and/or to withdraw additional hydrocarbons from the earth's formations. More recently, demand for drilling short to medium radius wellbores has been increasing. The term "short radius wellbores" generally means wellbores with radii between 12 and 30 meters, while the term "medium radius wellbores" generally means wellbores with radii between 30 and 300 meters.

Modern directional drilling systems generally employ a drilling assembly that includes a drill bit at its bottom end, which is rotated by a drill motor

(commonly referred to as the "mud motor") in the drilling assembly. The drilling assembly is conveyed into the wellbore by a coiled tubing. A fluid ("mud") under pressure is injected into the tubing which rotates the drilling motor and thus the drill bit. The state-of-the-art coiled-tubing drill conveyed drilling assemblies usually contain a drilling motor with a fixed bend and an orienting tool to rotate the high side of the drilling motor downhole in the correct direction. The currently available coiled-tubing drilling assemblies (systems) with such orienting tools are typically more than sixteen (16) meters long. Tools of such length are difficult to handle and difficult to trip into and out of the wellbore. Furthermore, such tools require long risers at the surface. Such orienting tools require relatively high power to operate due to the high torque of the drilling motor and the friction relating to the orienting tool.

To drill a short radius or medium radius wellbore it is highly desirable to be able to drill such wellbores with relative precision along desired or predetermined wellbore paths ("wellbore profiles"), and to alter the drilling direction downhole without the need to retrieve the drilling assembly to the surface. Drilling assemblies for use with coiled tubing to drill short-radius wellbores in the manner described above need a dedicated steering device, preferably near the drill bit, for steering and controlling the drill bit while drilling the wellbore. The device needs to be operable during drilling of the wellbore to cause the drill bit to alter the drilling direction.

The present invention provides drilling assemblies that address the above-noted needs. In one embodiment, the drilling assembly includes a steering device in a bearing assembly which is immediately above the drill bit.

The steering device may be operated to exert radial force in any one of several directions to articulate the drill bit along a desired drilling direction. The steering assembly may be disposed at other locations in the drilling assembly for drilling medium radius wellbores. Devices and/or sensors are provided in the drilling assembly to continuously determine the drilling assembly inclination, azimuth and direction. Other measurement-while-drilling ("MWD") devices or sensors may be utilized in the drilling assembly, as is known in the drilling industry.

SUMMARY OF THE INVENTION

The present invention provides a drilling assembly for drilling deviated wellbores. The drilling assembly contains a drill bit at the lower end of the drilling assembly. A motor provides the rotary power to the drill bit. A bearing assembly disposed between the motor and the drill bit provides lateral and axial support to the drill shaft connected to the drill bit. A steering device integrated into the drilling motor, preferably in the bearing assembly provides direction control during the drilling of the wellbores. The steering device contains a plurality of ribs disposed at an outer surface of the bearing housing. Each rib is adapted to move between a normal position or collapsed position in the housing and a radially extended position. Each rib exerts force on the wellbore interior when in the extended position. Power units to independently control the rib actions are disposed in the bearing assembly. An electric control unit or circuit controls the operation of the power units in response to certain sensors disposed in drilling assembly. Sensors to determine the amount of the force applied by each of the ribs on the wellbore are provided in the bearing section. The electric control circuit may be placed at a suitable location above the drilling motor or in the

rotating section of the drilling motor.

For drilling short radius wellbores, a knuckle joint or other suitable device may be disposed uphole of the steering device to provide a desired bend in the drilling assembly above the steering device. Electrical conductors are run from a power source above the motor to the various devices and sensors in the drilling assembly.

During drilling of a wellbore, the ribs start in their normal or collapsed positions near the housing. To alter the drilling direction, one or more ribs are activated, i.e., extended outwardly with a desired amount of force on each such rib. The amount of force on each rib is independently set and controlled.
The rib force produces a radial force on the drill bit causing the drill bit to alter the drilling direction.

Examples of the more important features of the invention thus have been summarized rather broadly in order that the detailed description thereof that follows may be better understood, and in order that the contributions to the art may be appreciated. There are, of course, additional features of the invention that will be described hereinafter and which will form the subject of the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

For detailed understanding of the present invention, references should be made to the following detailed description of the preferred embodiment, taken in

conjunction with the accompanying drawings, in which like elements have been given like numerals and wherein:

Figures 1A-1B show a cross-sectional view of a portion of the drilling assembly with the steering device and the control device disposed in the bearing assembly of the drilling assembly.

Figure 1C shows a rib of the steering device of in **Figure 1A** in an extended position.

Figure 2 is a schematic view of an alternative embodiment of a drilling assembly with steering members in the bearing assembly of the mud motor and the power and control devices for operating the steering members disposed above the mud motor.

Figure 3 is a schematic view of an alternative embodiment of a drilling assembly with steering members and the power and control devices for operating the steering members disposed above the mud motor.

Figure 4 is a schematic view of a configuration of the steering members disposed around a non-rotating housing for use in the steering devices of **Figures 1-4**.

Figure 5 is a schematic view of an alternative configuration of the steering members disposed around a non-rotating housing for use in the steering devices of **Figures 1-4**.

Figure 6 is a schematic drawing of an embodiment of the drilling assembly according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In general, the present invention provides a drilling assembly for use with coiled tubings to drill wellbores. The drilling assembly includes a drilling motor having a power section and a bearing assembly that provides radial and axial support to the drill bit. A steering device integrated into the bearing assembly provides directional control in response to one or more downhole measured parameters. The steering device included a plurality of independently controlled force application members, which are preferably controlled by a control unit or processor in response to one or more downhole measured parameters and predetermined directional models provided to the control unit.

Figures 1A-1B show a schematic diagram of a steering device **30** integrated into a bearing assembly **20** of a drilling motor **10**. The drilling motor **10** forms a part of the drilling assembly **100** (**Figure 2**). The drilling motor **10** contains a power section **12** and the bearing assembly **20**. The power section **12** includes a rotor **14** that rotates in a stator **16** when a fluid **52** under pressure passes through a series of openings **17** between the rotor **14** and the stator **16**. The fluid **52** may be a drilling fluid or "mud" commonly used for drilling wellbores or it may be a gas or a liquid and gas mixture. The rotor **14** is coupled to a rotatable shaft **18** for transferring rotary power generated by the drilling motor **10** to the drill bit **50**.

The bearing assembly **20** has an outer housing **22** and a through passage **24**. A drive shaft **28** disposed in the housing **22** is coupled to the rotor **14** via the rotatable shaft **18**. The drive shaft **28** is connected to the drill bit **50** at its lower or downhole end **51**. During drilling of the wellbores, drilling fluid **52** causes the rotor **14** to rotate, which rotates the shaft **18**, which in turn rotates the drive shaft **28** and hence the drill bit **50**.

The bearing assembly **20** contains within its housing **22** suitable radial bearings **56a** that provide lateral or radial support to the drive shaft **28** and the drill bit **12**, and suitable thrust bearings **56b** to provide axial (longitudinal or along wellbore) support to the drill bit **12**. The drive shaft **28** is coupled to the shaft **18** by a suitable coupling **44**. The shaft **18** is a flexible shaft to account for the eccentric rotation of the rotor. Any suitable coupling arrangement may be utilized to transfer rotational power from the rotor **14** to the drive shaft **28**. During the drilling of the wellbores, the drilling fluid **52** leaving the power section **14** enters the through passage **24** of the drive shaft **28** at ports or openings **46** and discharges at the drill bit bottom **53**. Various types of bearing assemblies are known in the art and are thus not described in greater detail here.

In the preferred embodiment of **Figures 1A-1B**, a steering device, generally represented by numeral **30** is integrated into the housing **22** of the bearing assembly **20**. The steering device **30** includes a number of force application members **32**. Each force application member is preferably placed in a reduced diameter section **34** of the bearing assembly housing **22**. The force application members may be ribs or pads. For the purpose of this invention, the

force application members are generally referred herein as the ribs. Three ribs **32**, equispaced around or in the outer surface of the housing **22**, have been found to be adequate for properly steering the drill bit **50** during drilling operations. Each rib **32** is adapted to be extended radially outward from the housing **22**. **Figure 1C** shows a rib **32** in its normal position **32a** (also referred to as the "retracted" or "collapsed" position) and in fully extended position **32b** relative to the wellbore inner wall **38**.

The operation of each steering rib **32** is independently controlled by a separate piston pump **40**. For short radius drilling assemblies, each such pump **40** is preferably an axial piston pump **40** disposed in the bearing assembly housing **22**. In one embodiment, the piston pumps **40** are hydraulically operated by the drill shaft **28** utilizing the drilling fluid **52** flowing through the bearing assembly **20**. A control valve **33** is disposed between each piston pump **40** and its associated steering rib **32** to control the flow of the hydraulic fluid from such piston pump **40** to its associated steering rib **32**. Each control valve **33** is controlled by an associated valve actuator **37**, which may be a solenoid, magnetostrictive device, electric motor, piezoelectric device or any other suitable device. To supply the hydraulic power or pressure to a particular steering rib **32**, the valve actuator **37** is activated to provide hydraulic power to the rib **32**. If the valve actuator **37** is deactivated, the check valve is blocked, and the piston pump **40** cannot create pressure in the rib **32**. During drilling, all piston pumps **40** are operated continuously by the drive shaft **28**. In one method, the duty cycle of the valve actuator **37** is controlled by processor or control circuit **80** disposed at a suitable place in the drilling assembly **100**. **Figure 1A** shows the control circuit **80** placed in the rotor **14** to conserve space. The control circuit may be placed at

any other location, including at a location above the power section **10**. Instead of using the hydraulic power to operate the pumps **40**, each pump **40** may be operated by electric motors suitably disposed in the bearing assembly **20**.

Still referring to **Figures 1A-1B**, it is known that the drilling direction can be controlled by applying a force on the drill bit **50** that deviates from the axis of the borehole tangent line. This can be explained by use of a force parallelogram depicted in **Figure 1A**. The borehole tangent line is the direction in which the normal force (or pressure) is applied on the drill bit **50** due to the weight on bit, as shown by the arrow **WOB 57**. The force vector that deviates from this tangent line is created by a side force applied to the drill bit **50** by the steering device **30**. If a side force such as that shown by arrow **59** (Rib Force) is applied to the drilling assembly **100**, it creates a force **54** on the drill bit **50** (Bit Force). The resulting force vector **55** then lies between the weight on bit force line (Bit Force) depending upon the amount of the applied Rib Force.

In the present invention, each rib **32** can be independently moved between its normal or collapsed position **32a** and an extended position **32b**. The required side force on the drilling assembly is created by activating one or more of the ribs **32**. The amount of force on each rib **32** can be controlled by controlling the pressure on the rib **32**. The pressure on each rib **32** is preferably controlled by proportional hydraulics or by switching to the maximum pressure (force) with a controlled duty cycle. The duty cycle is controlled by controlling the operation of the valve actuator **37** by any known method.

The use of axial piston pumps **40** enables disposing such pumps **40** in the bearing assembly and relatively close to the ribs **30**. This configuration can reduce the overall length of the drilling assembly. Placing the ribs **32** in the housing **22** of the bearing assembly **20** aids in drilling relatively shorter radius boreholes. The above-described arrangement of the steering device **30** and the ability to independently control the pressure on each rib **32** enables steering the drill bit **12** in any direction and further enables drilling the borehole with a controlled build-out rate (deviation angle). Preferably a separate sensor **39** is provided in the bearing assembly **20** to determine the amount of force applied by each rib **32** to the borehole interior **38**. The sensor **33** may be a pressure sensor, a position measuring sensor or a displacement sensor. The processor **80** processes the signals from the sensor **39** and in response thereto and stored information or models controls the operation of each rib **32** and thus precisely controls the drilling direction.

To achieve higher build-up rates ("BUR"), such as rates of more than 60°/100 feet, a knuckle joint **60** may be disposed between the motor power section **14** and the steering devices **30**. The knuckle joint **60** is coupled to the bearing assembly **20** at the coupling **44** and to the shaft **28** with a coupling joint **45**. The knuckle joint **60** can be set at one or more bent positions **62** to provide a desired bend angle between the bearing assembly **20** and the motor power section **14**. The use of knuckle joints **60** is known in the art and thus is not described in detail herein. Any other suitable device for creating the desired bend in the drilling assembly **100** may be utilized for the purpose of this invention.

Electric conductors **65** are run from an upper end **11** of drilling motor **10** to the bearing assembly **20** for providing required electric power to the valve actuators **33** and other devices and sensors in the drilling motor **10** and to transit data and signals between the drilling motor **10** and other devices in the system. The rotor **14** and the shaft **28** may be hollow to run conductors **65** therethrough. Appropriate feed-through connectors or couplings, such as coupling **63**, are utilized, where necessary, to run the electric conductors **65** though the drilling motor **10**. An electric slip ring device **70** in the bearing assembly **20** and a swivel (not shown) at the top of the power section **12** is preferably utilized to pass the conductors **65** to the non-rotating parts in the bearing assembly **20**. Electric swivel and slip rings may be replaced by an inductive transmission device. The devices and sensors such as pressure sensors, temperature sensors, sensors to provide axial and radial displacement of the drill shaft **28** are preferably included in the drilling motor **10** to provide data about selected parameters during drilling of the boreholes.

Figure 2 is a schematic view of an alternative embodiment of a drilling assembly **100** with steering members **30** in the bearing assembly **20** of the mud motor **10** and the power and control devices **90** for operating the steering members **30** disposed above the power section **12** of the mud motor **10**. In this configuration the rotor **14** is coupled to the drill shaft **28** by a suitable coupling or flexible shaft **19**. A common housing **92** with or without connection joints **93** may be used to house the stator **16**, coupling **19** and the bearing assembly **20**. A separate fluid line **91** is run from a source of hydraulic power in section **90** to each of the individual force application members **30** through the housing **92**. The section **90** contains the pumps and the control valves and the required control

circuits to independently control the operation of each of the ribs **30**. This configuration is simpler than the configuration that contains the power and/or control devices in the mud motor **10**, more reliable as it does not require using mechanical and electrical connections inside the bearing housing **22**. It also enables building reduced overall length mud motors **10** compared to the configuration shown in **Figure 1**. The configuration of **Figure 2** allows drilling of the wellbores with a higher build up rate compared due the proximity of the ribs **30** near the drill bit **50** and the shorter length of the drilling motor **10**. A stabilizer **83** is provided at a suitable location uphole of the ribs **30** to provide lateral stability to the drilling assembly **100**. Alternatively, a second set of ribs **30** may be incorporated into the drilling assembly as described below.

Figure 3 is a schematic view of drilling assembly configuration wherein the ribs **30** are placed above the mud motor **10** and the power unit and the control devices to control the operation of the ribs is disposed in a suitable section above the mud motor **10**. A hydraulic line **93** provides the fluid to the ribs **30**. The operation of the steering devices shown in **Figures 2** and **Figure 3** are similar to the operation of the embodiment of **Figures 1A-1C**. In yet another configuration, the ribs **30** may be placed in the bearing assembly **20** as shown in **Figure 3** and also above the motor **10** as shown in **Figure 4**. In such a configuration, a separate line is run for each of the ribs. A common control circuit and a common hydraulic power unit may be used for all the ribs with each rib having a separate associated control valve. This configuration allows to control the drilling direction at multiple location on the drilling assembly.

Figure 4 is a schematic view of a configuration showing three force application members **32a-32c** disposed around the non-rotating housing **22** of the bearing assembly **20** of **Figures 1-4**. The configuration of **Figure 4** shows three force application members **32a-32c** placed spaced apart around the periphery of the bearing assembly housing **22**. The force application members **32a-32c** are identical and thus the configuration and operation thereof is described with respect to only the member **32a**. The force application member **32a** includes a rib member **102a** that is radially movable as shown by the arrows **108a**. A hydraulically-operated piston **104a** in a chamber **106a** acts on the rib member **102a** to moves the rib member **102a** outward to cause it to apply force to the wellbore. The fluid is supplied to the chamber **106a** from its associated power source via a port **108a**. As described earlier, each force application member is independently operated to control the amount of the force exerted by such member to the wellbore inside, which allows precisely controlling the drilling direction of the wellbore. The force application members **32b** and **32c** respectively include pistons **104b** and **104c**, chambers **106b** and **106c** and inlet ports **108b** and **108c** and they move in the directions shown by the arrows **110b** and **110c**. **Figure 5** is a schematic view of an alternative configuration of the steering members. This configuration differs from the configuration of **Figure 4** in that it does not have the rib members. The pistons **112a-112c** directly apply the force on the wellbore walls the pistons are extended outward.

Figure 6 shows a configuration of a drilling assembly **100** utilizing the steering device **30** (see **Figures 1A-1B**) of the present invention in the bearing assembly **20** coupled to a coiled tubing **202**. The drilling assembly **100** has the drill bit **50** at the lower end. As described earlier, the bearing assembly **20** above

the drill bit **50** carries the steering device **30** having a number of ribs that are independently controlled to exert desired force on the drill bit **50** during drilling of the boreholes. An inclinometer (z-axis) **234** is preferably placed near the drill bit **50** to determine the inclination of the drilling assembly. The mud motor **10** provides the required rotary force to the drill bit **50** as described earlier with reference to **Figures 1A-1B**. A knuckle joint **60** may be provided between the bearing assembly **20** and the mud motor **10**. Depending upon the drilling requirements, the knuckle joint **60** may be omitted or placed at another suitable location in the drilling assembly **100**. A number of desired sensors, generally denoted by numerals **232a-232n** may be disposed in a motor assembly housing **15** or at any other suitable place in the assembly **100**. The sensors **232-232n** may include a resistivity sensor, a gamma ray detector, and sensors for determining borehole parameters such as temperature and pressure, and drilling motor parameters such as the fluid flow rate through the drilling motor **10**, pressure drop across the drilling motor **10**, torque on the drilling motor **10** and speed of the motor **10**.

The control circuit **80** may be placed above the power section **12** to control the operation of the steering device **30**. A slip ring transducer **221** may also placed in the section **220**. The control circuits in the section **220** may be placed in a rotating chamber which rotates with the motor. The drilling assembly **100** may include any number of other devices. It may include navigation devices **222** to provide information about parameters that may be utilized downhole or at the surface to control the drilling operations and/or devices to provide information about the true location of the drill bit **50** and/or the azimuth. Flexible subs, release tools with cable bypass, generally denoted herein by numeral **224**, may

also be included in the drilling assembly **100**. The drilling assembly **100** may also include any number of additional devices known as the measurement-while-drilling devices or logging-while-drilling devices for determining various borehole and formation parameters, such as the porosity of the formations, density of the formation, and bed boundary information. The electronic circuitry that includes microprocessors, memory devices and other required circuits is preferably placed in the section **230** or in an adjacent section (not shown). A two-way telemetry **240** provides two-way communication of data between the drilling assembly **100** and the surface equipment. Conductors **65** placed along the length of the coiled-tubing may be utilized to provide power to the downhole devices and the two-way data transmission.

The downhole electronics in the section **220** and/or **230** may be provided with various models and programmed instructions for controlling certain functions of the drilling assembly **100** downhole. A desired drilling profile may be stored in the drilling assembly **100**. During drilling, data/signals from the inclinometer **234** and other sensors in the sections **222** and **230** are processed to determine the drilling direction relative to the desired direction. The control device, in response to such information, adjusts the force on force application members **32** to cause the drill bit **50** to drill the wellbore along the desired direction. Thus, the drilling assembly **100** of the present invention can be utilized to drill short-radius and medium radius wellbores relatively accurately and, if desired, automatically.

The foregoing description is directed to particular embodiments of the present invention for the purpose of illustration and explanation. It will be apparent, however, to one skilled in the art that many modifications and changes

to the embodiment set forth above are possible without departing from the scope and the spirit of the invention. It is intended that the following claims be interpreted to embrace all such modifications and changes.

WHAT IS CLAIMED IS:

1. A coiled tubing conveyed drilling assembly for use in drilling of a wellbore, comprising:

(a) a drilling motor for generating a rotary force in response to the flow of a drilling fluid through the drilling motor; and

(b) a steering device integrated into the drilling motor for altering the drilling direction of the wellbore, said steering device including:

(i) a plurality of force application members arranged around a section of the drilling motor, each said force application member extending radially outward from the drilling motor to apply force to the wellbore inside, upon the application of power thereto;

(ii) a power unit for supplying power to the force application members; and

(iii) a separate control device for controlling the supply of the power to the force application members.

2. The drilling assembly according to claim 1, wherein the power unit includes a pump for supplying pressurized fluid to the force application members.

3. The drilling assembly according to claim 1, wherein the power unit includes a separate electric motor associated with each control device, each said electric motor controlling a linear motion of its control device to move the force application member between a normal position and an extended position.

4. The drilling assembly according to claim 1 further comprising a control circuit for controlling the operation of the control devices.

5. The drilling assembly according to claim 4, wherein the control circuit is placed in a rotating part of the drilling motor.

6. The drilling assembly according to claim 1, wherein the drilling motor includes a power section and a bearing assembly and wherein the steering device is integrated in the bearing assembly.

7. The drilling assembly according to claim 1, wherein each control device is a fluid control valve.

8. The drilling assembly according to claim 1, wherein the power unit includes a pump for supplying a pressurized fluid to each of the force application members to move each said force application member between a normal position and a radially-extended position.

9. The drilling assembly according to claim 1, wherein the power unit includes a separate pump associated with each said force application member for moving each force application member between a normal position and a radially-extended position.

10. The drilling assembly according to claim 7 further comprising a valve actuator for each said control valve for controlling the operation of such control valve.

11. The drilling assembly according to claim 10, wherein the valve actuator is selected from a group consisting of (a) a solenoid; (b) a magnetostrictive device; (c) an electric motor; and (d) a piezoelectric device.

12. The drilling assembly according to claim 11, wherein the valve actuator is duty cycled to control the supply of a pressurized fluid to its associated force application member.

13. The drilling assembly according to claim 1, wherein the power unit is operated by one of (a) a rotating shaft associated with the drilling motor, and (b) an electric motor.

14. The drilling assembly according to claim 1, wherein the drilling fluid is selected from a group of fluids consisting of a (i) liquid, (ii) gas, and (iii) liquid-gas mixture.

15. The drilling assembly according to claim 1, wherein each force application member includes a piston that radially moves a rib member of the force application member upon receiving the pressurized fluid from the power unit.

16. The drilling assembly according to claim 1 further having a sensor associated with each force application member for providing signals indicative of the position of each such force application member relative to a reference position.

17. The drilling assembly according to claim 16 wherein the control circuit independently controls the operation of each force application member in response to the measurements of the sensors and according to instructions provided thereto.

18. A coiled tubing conveyed drilling assembly for use in drilling a wellbore, said drilling assembly comprising:

(a) a drilling motor having an outer housing, said drilling motor generating a rotary force in response to the flow of a pressurized fluid through the drilling motor; and

(b) a first plurality of hydraulically-operated force application members arranged around an outer surface of the housing, each said force application member extending radially outward from the housing upon the supply of a pressurized fluid thereto to apply force to the wellbore inside;

(c) a power unit disposed uphole of the drilling motor for supplying hydraulic power to the force application members; and

(d) a separate conduit in the housing associated with each of the force application members for supplying the pressurized fluid from the power unit to its associated force application member.

19. The drilling assembly according to claim 18, further comprising a separate fluid control device associated with each force application member for controlling the supply of the pressurized fluid from the power unit to its associated force application member.

20 The drilling assembly according to claim 18 further comprising a second plurality of force application members on the drilling assembly and spaced apart from the first plurality of force application members.

21. The drilling assembly according to claim 20, wherein the second plurality of force application members receive pressurized fluid from the power unit in the drilling assembly and are controlled by the control circuit.

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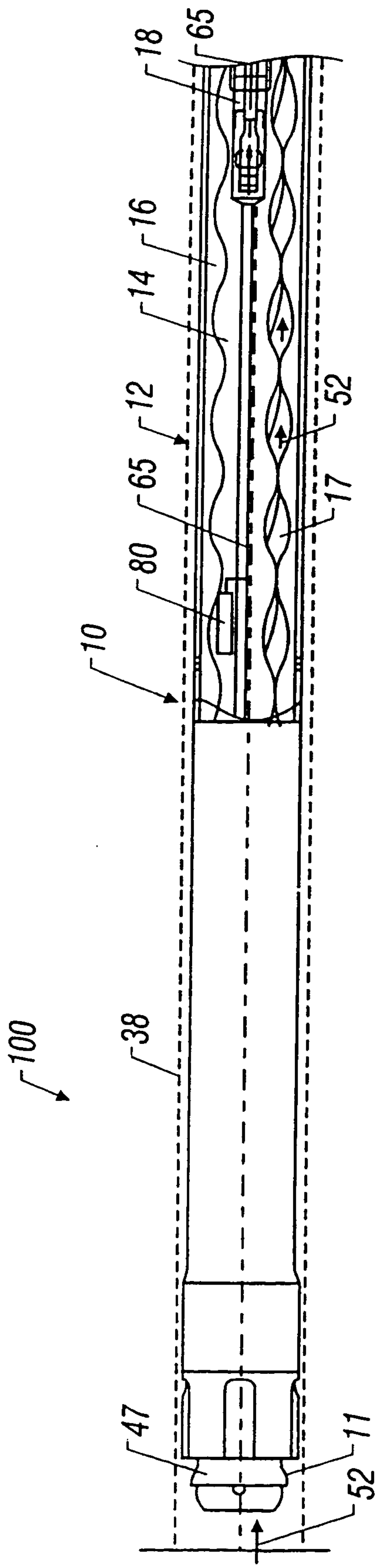


Figure 1A

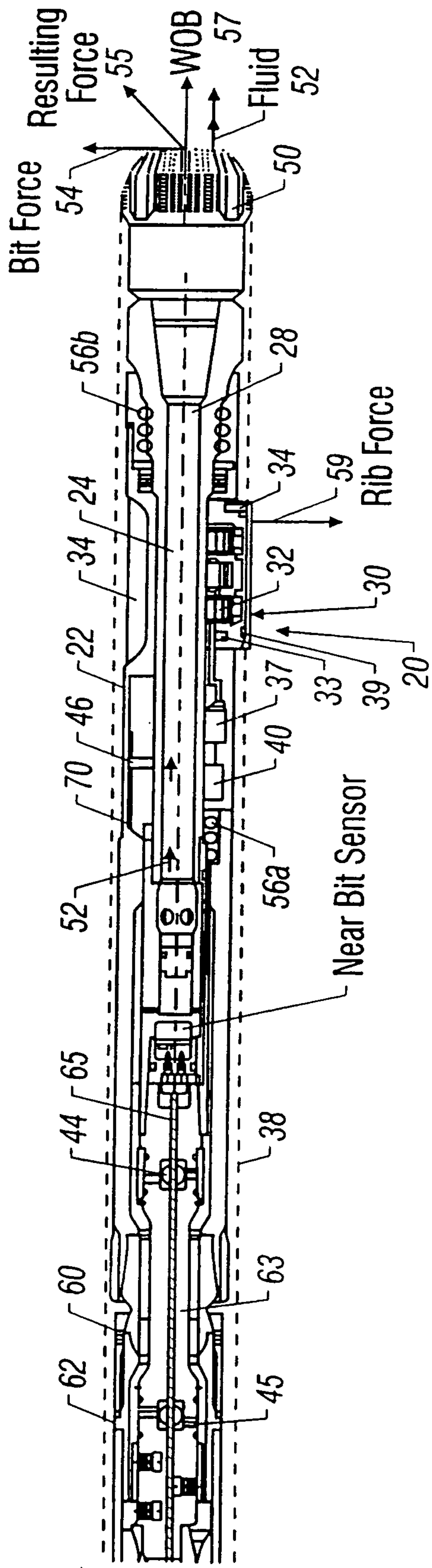


Figure 1B

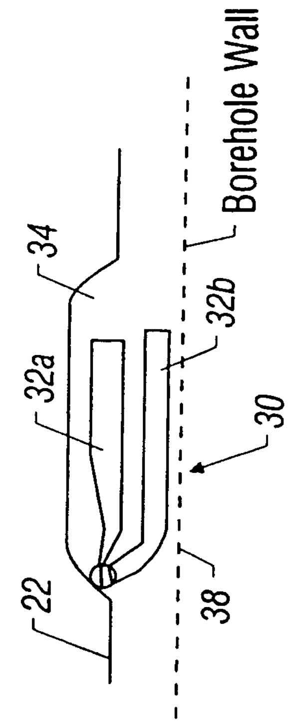


Figure 1C

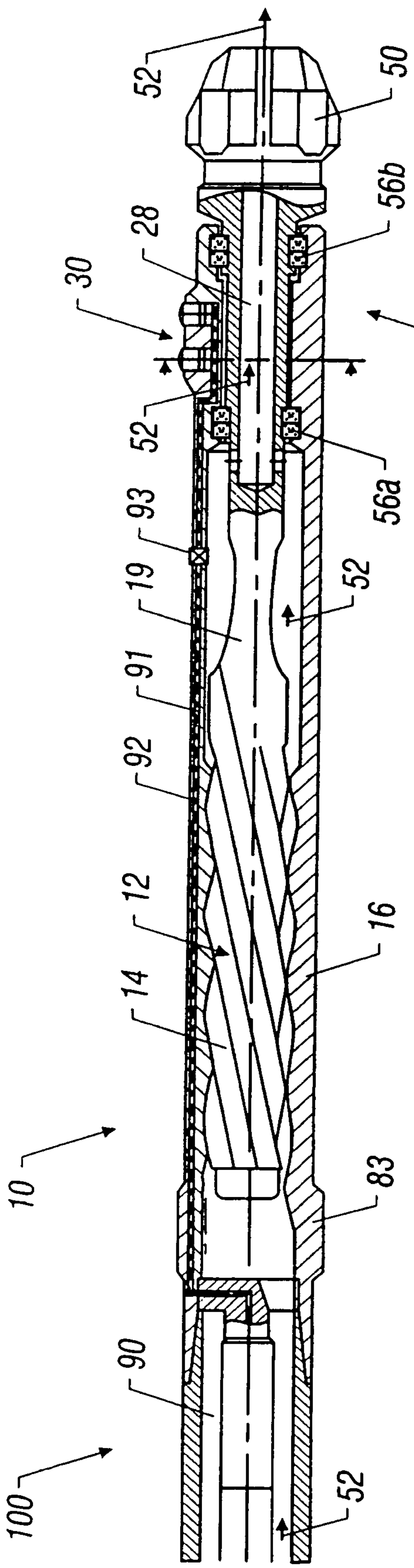


Figure 2

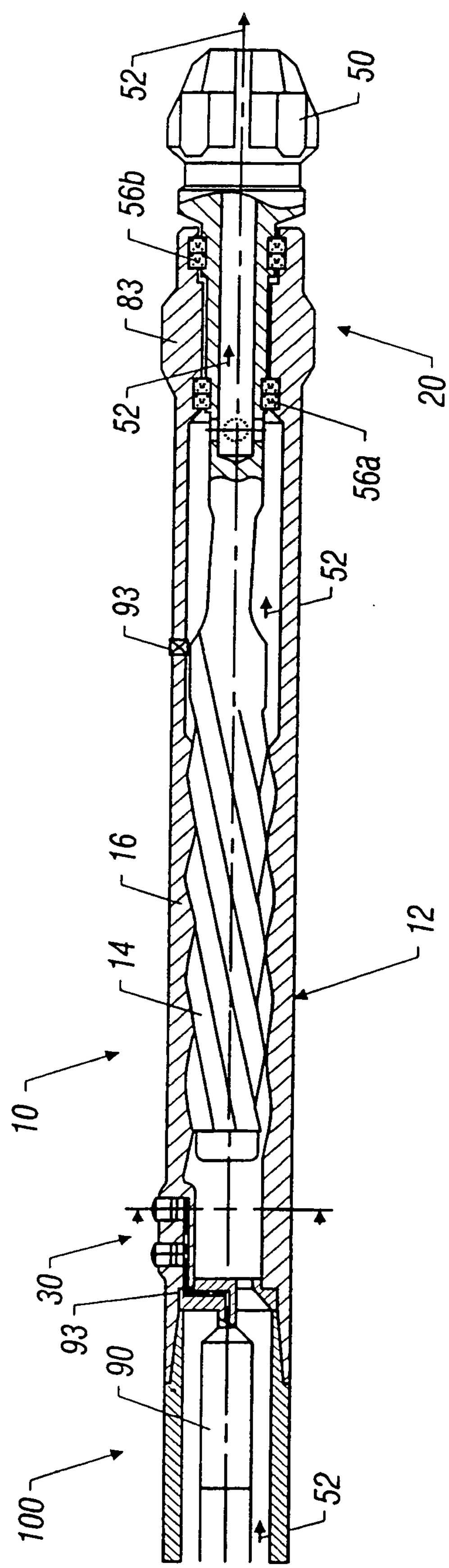
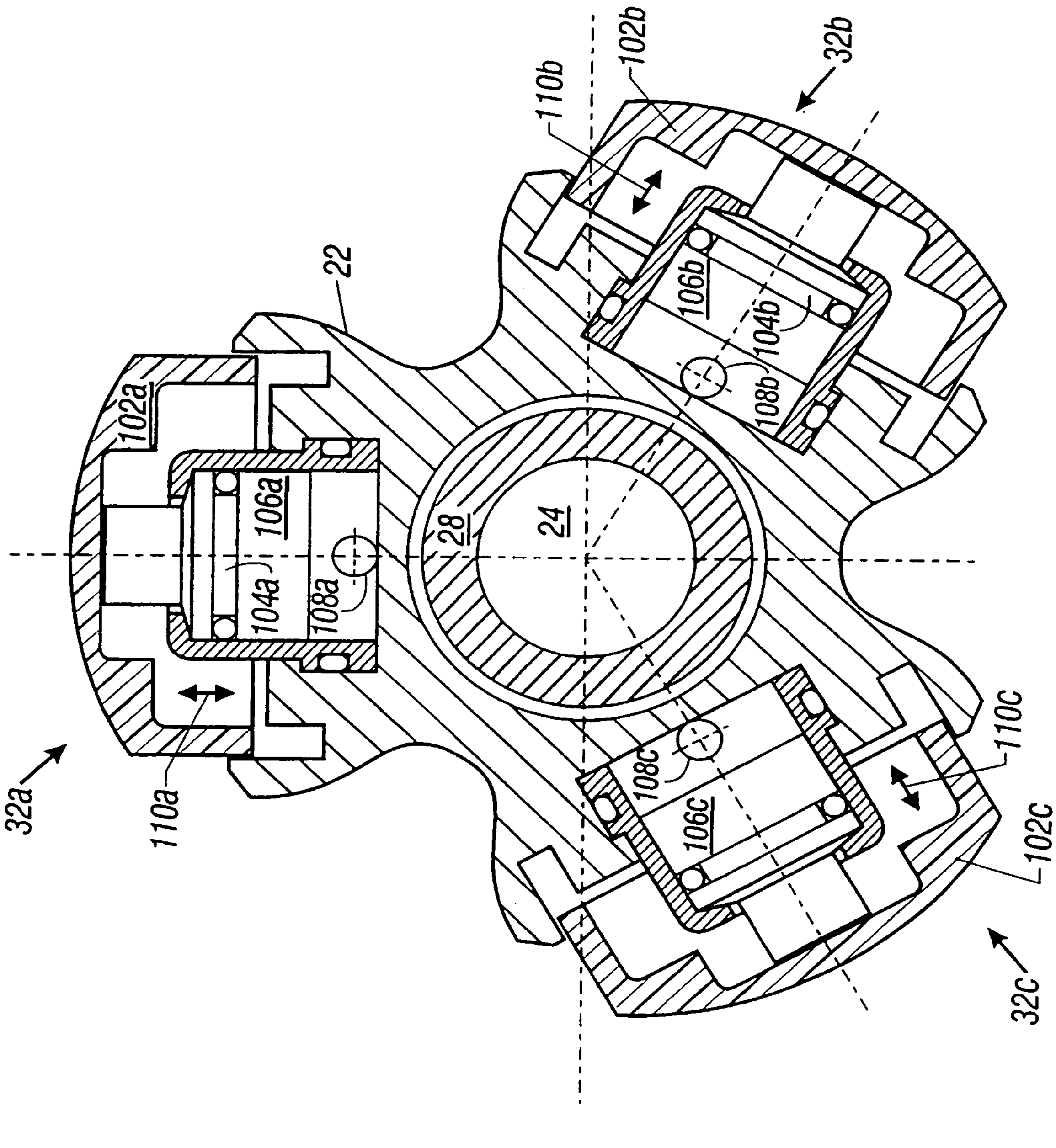


Figure 3



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32b
32c
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108c
110a
110b
110c

Figure 4

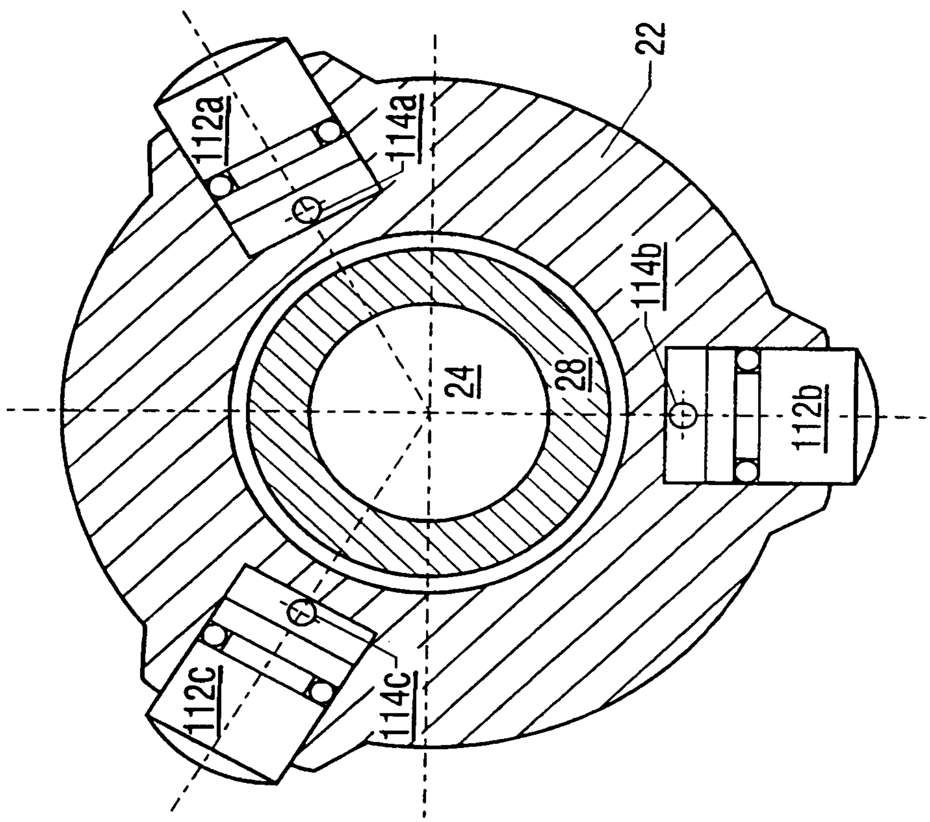
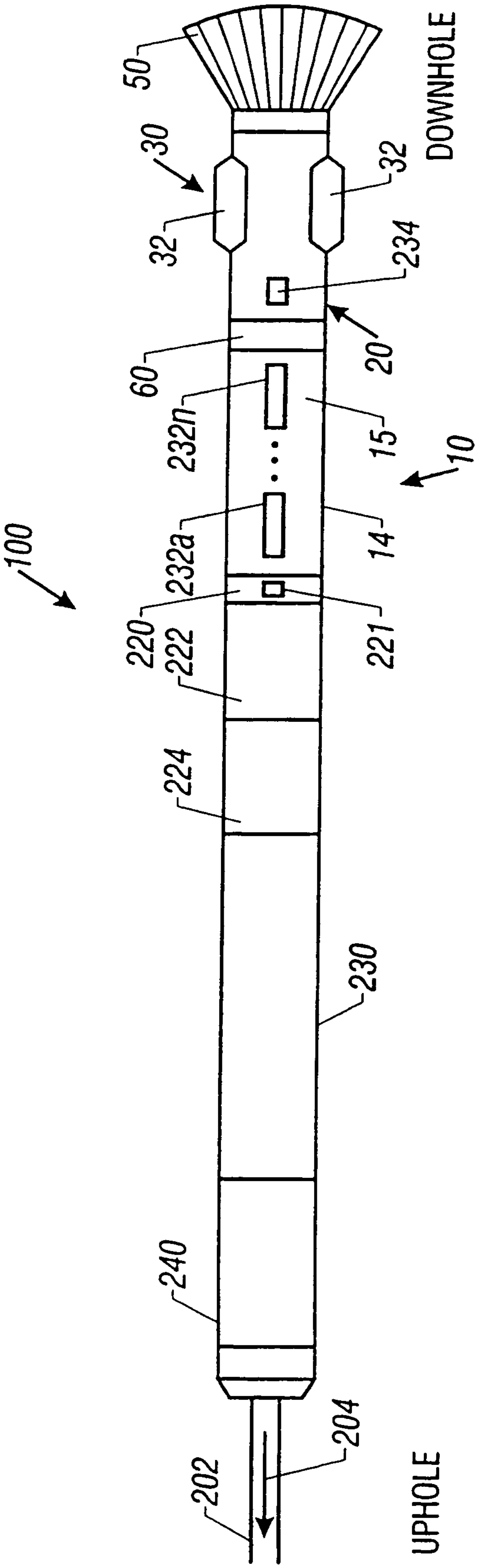


Figure 5



DOWNHOLE
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100
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UPHOLE

Figure 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/01681

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E21B7/06 E21B17/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 463 814 A (HORSTMEYER ROBERT J ET AL) 7 August 1984 see page 3, line 51 - page 10, line 21 see figures 1-14	18-21
Y		1,2,4, 6-8, 10-17
Y	US 5 332 048 A (UNDERWOOD LANCE D ET AL) 26 July 1994 see column 6, line 62 - column 7, line 2	1,2,4, 6-8, 10-17
A	US 5 139 094 A (PREVEDEL BERNHARD ET AL) 18 August 1992 see column 2, line 59 - column 10, line 68 see figures 1-10	1,18

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
16 April 1998	23/04/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Schouten, A

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International Application No
PCT/US 98/01681

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 947 944 A (COLTMAN TREVELLYN M ET AL) 14 August 1990 see column 7, line 3-54 see figure 8 -----	3

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 98/01681

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 5332048 A	26-07-94	CA 2108918 A	24-04-94
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